The Lifecycle of Space Science Missions

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NASA's Office of Space Science (OSS) program consists of three components: research, mission development, and mission operations and data analysis. For the third of these components, OSS uses a biennial review process to assess the scientific productivity of its operating space science missions, and to make decisions on whether or not to extend mission observing programs beyond their previously agreed end dates on the basis of their scientific relevance. The purpose of this "White Paper" is to describe the three core elements of the space science process, and to explain the decision-making process for each of the phases of a mission.

The Science "Cycle"

Broadly speaking, the science cycle consists of three steps necessary to obtain the desired scientific outcome.

- Research (sometimes called "Research and Analysis" - R&A) which gives rise to mission concepts and tests key instrumentation: theoretical studies, new instrument development, exploratory or supporting ground-based and sub orbital research.
- Flight Mission Development: mission studies, development, launch, in-orbit checkout or interplanetary flight to the first target.
- Mission Operations and Data Analysis (MO&DA): To make the planned observations, analyze and interpret the data, confirm or revise theoretical models. This usually leads to follow-up questions or hypotheses, which require new or improved instrumentation to form the next cycle of research, development, and observations and data analysis.

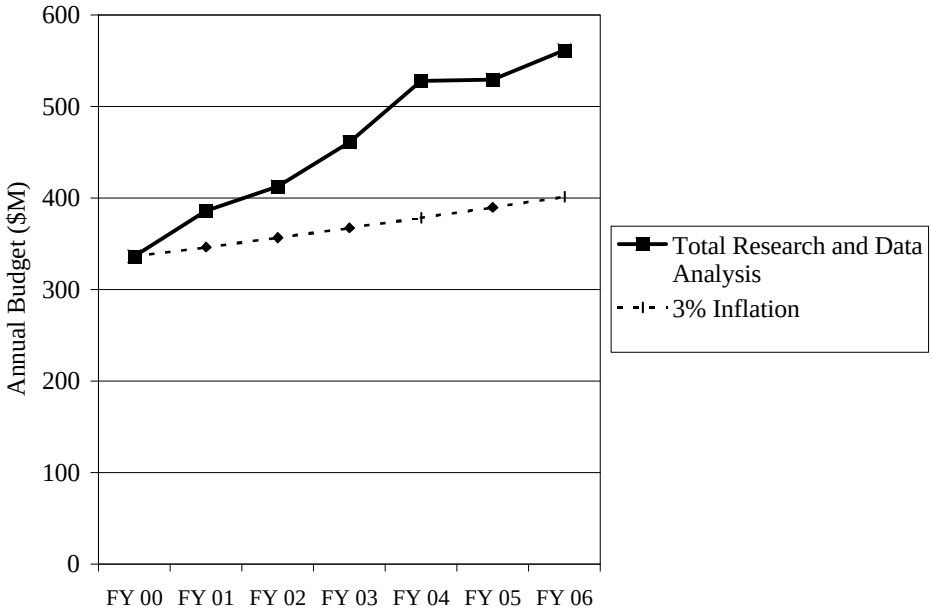
Three Avenues for Participation in the Space Science Cycle

- Research: To be successful in the competition for space science R&A funding, proposers typically have some degree of specialization and research infrastructure. OSS issues annual calls for proposals in all space science research disciplines. The typical award duration is 3 years and oversubscription typically ranges from 3: 1 to 5 : 1. The OSS research budget in fiscal year 2000 (FY00) is $250M; after subtracting taxes, earmarks, and other expenses, the "net" research budget is $164M. Universities typically win 60% - 70% of research awards
- For Flight Mission Development (instruments or whole missions), proposers must have highly specialized, world-class expertise. Opportunities are as frequent as once per 18 months for certain mission "lines"; oversubscription can reach 30: 1. Typical award durations are 5 - 10 years. The FY00 budget for mission development is $1,503M, of which universities typically receive ~ 12%.
- Mission Operations and Data Analysis Programs are the best opportunity for "new" entrants to be selected for funding. Astrophysics has substantial data analysis programs with annual, fully open proposal solicitations. Most awards have 1-year duration, although a few "key" observing programs require multi-year observing sequences. Proposal oversubscription ranges from 2: 1 to 6 : 1; universities receive ~ 75% of awards. OSS is systematically adding similar DA programs to planetary and other space science missions, even for

missions, which were selected in "PI Mode". The total MO&DA budget for FY00 is $406M subtracting costs of operations, data processing and archiving results in a net DA-only budget of $172M

Funding Trend for Research and Data Analysis

In 1998, the National Research Council's Space Studies Board (SSB) published a report on "Supporting Research and Data Analysis in NASA's Science Programs." It emphasized that of all the components of NASA's Space Science program, the R&A and the DA components are the most accessible to the larger space science research community. As part of the current budget formulation cycle, OSS is therefore proposing to systematically boost the R&DA budget. For example, OSS will attach new DA lines to all current or new missions, which could benefit from an open DA program. Furthermore, new R&A components are part of all new initiative requests. In contrast to the constant R&A budget lines in the past 5 years for the traditional Space Science disciplines, an inflation increase will be added to the research budget beginning in FY02. As shown in the following chart, the result of all these changes is that the total R&DA budget will increase, on average, by almost 10% per year between FY00 and FY06 – much faster than inflation!



To Extend - or Not To Extend - a Mission

Each mission is proposed - and selected via science peer review - for a specific agreed-upon observing period called the "prime phase;" it has a fixed end date. Proposers design this prime phase so that all observations can be completed that are required to meet the mission's science objectives. Only if - based on independent external science reviews ("Senior Reviews") – there is a strong reason for continuing specific observations, e.g. to follow up on new discoveries, NASA will approve an extension. Missions are never planned to be operated in perpetuity, but for a carefully planned finite length of time. Still, more than half of the OSS missions currently operating have been extended significantly beyond their prime phase for scientific reasons.

A specific example is the Extreme Ultraviolet Explorer (EUVE) Mission, which was originally planned to have an operating lifetime of 3.5 years. After launch in June 1992, the agreed-upon mission completion date was January 1996. Through the "Senior Review" process for science-based decision-making, EUVE was granted two extensions in 1996 and 1998, first for very specific scientific observations, and then for cross-calibration with the Chandra X-Ray Observatory. Now that those objectives have been met, this year's Senior Review panel (composed primarily of astrophysicists from the university research community) saw no justification for another extension and recommended mission termination. The Senior Review report states, "The potential for new discoveries with this mature mission is low". Based on the Senior Review panel's science assessment and completion recommendation, NASA decided to end the EUVE project at the end of year 2000, almost five years after the originally planned end of the mission. This was a science decision, not a funding issue. Contrary to information contained in some letter-writing campaigns, OSS did not reduce MO&DA funds for EUVE or any other mission reviewed in this year's Senior Review below the previously agreed-upon budget plans.

The full text of the panel reports for Senior Reviews 96, 98, and 00 can be found on the NASA Space Science web site at www.spacescience.nasa.gov/codesr/welcome.html. Readers are invited to examine the mission-by-mission science assessments, priorities and recommendations to NASA on mission completion or mission extension.

Balancing the Three Components of the Space Science Program: Research, Mission Development, and Data Analysis.

The above-mentioned SSB report contains six sets of detailed recommendations including "Evaluate the Balance between the Funding Allocations for Flight Programs and the R&DA to Support Those Programs." OSS is already making relatively small adjustments between flight program lines and the related MO&DA program lines. These adjustments, after Congressional approval, sometimes move a few $M from development lines to MO&DA, and sometimes in the opposite direction.

A more fundamental question is whether large-scale adjustments between flight development, research, and DA are needed. NASA's Office of Space Science has not received recommendations from the science community (except for a few individuals) for large-scale adjustments. Therefore, OSS does not propose to make large-scale transfers between the three components of the Space Science program at this time. However, OSS has received recommendations for specific small adjustments. For example, the National Research Council's "Decadal Survey" for Astrophysics recommended attaching a theory component ("Theory Challenges") to new Astrophysics missions since "theory lags behind data" in several sub disciplines.

What Do You Think?

NASA welcomes a dialog with the space science community whether at universities, NASA centers, in industry, or other organizations. Assuming fixed resources, important decisions need to be made by the science community about the balance between the various Space Science components. Should larger changes between the space science components be made? Should new, developing missions be delayed or canceled to boost research and/or MO&DA for operating missions? Should NASA support fewer mission extensions in order to free funds for research

and/or development? Comments and recommendations are invited to the Space Science Advisory Committees (http://spacescience.nasa.gov/advisory.htm) or to the author at griegler@hq.nasa.gov.